

REFLECTANCE SPECTROSCOPY OF DEUTERIUM-RICH CLUSTER IDPS. Lindsay P. Keller¹ and Scott Messenger², ¹MVA, Inc. 5500 Oakbrook Parkway, Suite 200, Norcross, GA 30093 (E-mail: lkeller@mva-inc.com). ²McDonnell Center for Space Sciences, Washington University, St. Louis, MO 63130 (E-mail: scott@ionprobe.wustl.edu).

Recent ion microprobe analyses of cluster IDPs have shown that many exhibit large enrichments in deuterium, and that these enrichments are larger, and more common, than those in individual interplanetary dust particles (IDPs) and in primitive meteorites [1]. The presence of the D enrichments indicates that these particles retain at least some presolar material, and the magnitude of the δD suggests that cluster IDPs may be some of the most isotopically primitive materials available for study. In this work, reflectance spectra over the visible wavelength range (~380-850 nm) were obtained from multiple fragments of known D-rich cluster IDPs in order to compare and contrast their spectra with remotely-sensed data from primitive solar system objects such as the outer asteroids and comets.

For the reflectance measurements, the cluster IDP fragments were placed on glass microscope slides, and multiple spectra were collected using a Zeiss MPM400 microscope photometer. Spectra were obtained over the wavelength range of 380-850 nm in 5 nm increments using dark-field illumination (oblique illumination at an angle of 30° to the sample), relative to a BaSO₄ reflectance standard. Details of the micro-reflectance spectroscopy methods are given in [2].

Spectra were obtained from 2 or 3 fragments of 6 different clusters from large area collectors L2005, L2009, and L2011. Although the parent clusters are known to be D-rich, we have not yet measured the isotopic composition of these subfragments to determine if they are also D-rich. For these fragments, the bulk compositions (including C abundances) were obtained using SEM/EDX techniques. Following the reflectance measurements, selected particles were embedded in elemental sulfur, thin sections were obtained using ultramicrotomy and analyzed in the transmission electron microscope (TEM), while the remainder of the particle was analyzed in the ion microprobe.

The reflectance data for the cluster IDP fragments are collected in Figure 1. The spectra have a number of characteristics in common including: 1) the D-rich cluster IDP fragments are all spectrally dark, with reflectivities of ~5-8% at 550 nm, 2) of the 6 cluster IDPs sampled, all but 1 contain fragments with reddened slopes over much of the visible wavelength range, with the exception, L2005, cluster 31, showing generally flat spectra over the visible, 3) many of the cluster IDP fragments show a distinctive broad feature centered at ~520 nm, but which extends from ~450-700 nm. This feature is characterized by distinct slope changes at ~450 nm and at ~680 nm and is particularly apparent in spectra from L2009, clusters 13 and 10, and in L2011 cluster 11, and finally, 4) all spectra show a pronounced drop off below ~420 nm similar to other analyzed IDPs, however, it is not clear whether this is a true measure of the indigenous reflectance characteristics of the particles or whether it is simply an artifact that results from the grain-size of the subcomponents of the particles approaching

the wavelength of light [2]. The fragments from L2009 clusters 7, 10, and 13 have relatively uniform reflectance, with little variation in their spectral shape and absolute reflectivities. However, the fragments from the L2005 and L2011 clusters show substantial intercluster variation in both their spectral slope and albedo. Similar heterogeneity is observed in other cluster IDPs where the spectral variations can be related to mineralogical and chemical differences between fragments [3].

In general, the broad feature at ~520 nm present in the spectra from the D-rich cluster fragments is absent from previously analyzed fragments of cluster IDPs as well as spectra from individual IDPs. Bradley *et al.* [2] noted that chondritic-smooth IDPs (CS, largely phyllosilicate dominated particles) were dark (<15% reflectance) and had flat slopes or showed a fall off into the near infrared, whereas the chondritic-porous subset of IDPs (CP, dominated by anhydrous silicates such as olivine or pyroxene) were also dark, but showed reddened slopes. In terms of albedo and spectral slope, the D-rich cluster fragments are most similar to the CP subset of IDPs, especially the CP IDPs that contain abundant carbonaceous material [2]. Known cometary IDPs belong predominantly to the CP subset, and are identified using He release temperature data (cometary particles enter the atmosphere with high velocity which results in a high He release temperature, whereas asteroidal particles have low entry velocities) [4].

The spectra from the D-rich cluster fragments are different from published spectra of chondritic meteorites. While certain of the carbonaceous chondrites are as spectrally dark as the D-rich cluster fragments, most show flat slopes or a fall off into the near infrared [e.g. 5]. Visible reflectance spectra from low-albedo asteroids (mostly P- and D-type) [6] and some comet nuclei [7] resemble the D-rich cluster fragment spectra in terms of their albedo and reddened slopes, however, a distinct 520 nm feature has not been observed in the asteroid and comet spectra.

The low reflectivities combined with the reddened slopes of the deuterium-rich cluster IDP spectra are most similar to spectra obtained from D asteroids and some comet nuclei. The broad feature in the reflectance spectra at ~520 nm is common in these particles, although it is unknown whether this feature is related to a D-rich phase or some other component in the fragments. The phase(s) responsible for this feature are presently under investigation. All of these D-rich clusters are known to contain concentrations of polyaromatic hydrocarbons (PAHs) [1], which may influence the slope of the reflectance spectra.

References. [1] Messenger, S. *et al.*, 1996, *LPSC* 27, 867. [2] Bradley, J. P. *et al.*, 1996, *MPS* 31, 394, [3] Thomas, K. L. *et al.*, 1995, *Geochim. Cosmochim. Acta*, 59, 2797, [4] Brownlee, D. E. *et al.*, 1995, *LPSC* 25, 185, [5] Hiroi, T. *et al.* 1993, *LPSC* 24, 659, [6] Vilas, F. *et al.*, 1993, *Icarus*, 105, 67. Luu, J. X. 1993, *Icarus*, 104, 138.

Figure 1. Reflectance spectra (380-850 nm) from multiple fragments of deuterium-rich cluster IDPs from large-area collectors L2005, L2009, and L2011.

